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SUBSTANTIVE THEMES SELECTED FOR DETAILED CONSIDERATION: CONTRIBUTION OF NEW AND RENEWABLE SOURCES OF ENERGY TO DECENTRALIZED ENERGY SYSTEMS AND TO SPECIFIC MULTI-PURPOSE MEDIUM- TO LARGE-SCALE APPLICATIONS

Contribution of new and renewable sources of energy to decentralized energy systems and to specific multi-purpose medium- to large-scale applications

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INTRODUCTION

1. At its fifth session, the Committee on the Development and Utilization of New and Renewable Sources of Energy decided to include for detailed consideration at its sixth session a theme on the contribution of new and renewable sources of energy to decentralized energy systems and to specific multi-purpose medium- to large-scale applications, and requested the Secretary-General to prepare a report for its consideration at its sixth session based on an in-depth study of the current stage of achievement in States regarding the theme. 1/ The present report was prepared in response to that request. The report describes decentralized, and medium- to large-scale applications of solar energy, wind energy, hydropower, geothermal energy, biomass, peat, oil shale and tar sands, and ocean energy. It is based on information provided by some member States and supplemented by published sources.

2. In adopting the theme for full consideration, the Committee was expressing the increasing concern of the international community at the general lack of progress in meeting the energy needs of the great majority of the developing countries, particularly in rural areas. The United Nations Conference on New and Renewable Sources of Energy, held in 1981, and the Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy, adopted at that Conference, 2/ generated hopes and expectations that developments in new and renewable sources of energy could make a significant contribution in rural areas, with their needs for decentralized systems. Vast resources such as biomass and hydropower potential were known, and optimism prevailed that cost-effective technological breakthroughs were possible, particularly for solar and wind power, provided that adequate resources were devoted by both Governments and private enterprises, especially in research and development.

3. As reported by the Intergovernmental Group of Experts on New and Renewable Sources of Energy, 3/ these hopes and expectations have largely failed to materialize. Yet the problem remains even more urgent than at the time of the 1981 Conference. The 1980s have witnessed a massive deterioration in the economic development prospects of most developing countries. Foreign indebtedness, adverse terms of trade, political instability, armed conflicts, natural disasters and inappropriate domestic policies have all led to very slow and even negative economic growth and per capita incomes. As shown in table 1, agricultural incomes per worker have hardly improved in any of the regions of the developing world. In South-East Asia and sub-Saharan Africa there was even an absolute drop from already low levels of less than US$ 1 (1980 prices) per day per capita. Poverty has been extended to more people, and its impact has been pervasive, particularly in rural areas. National governmental policies aimed at more balanced and equitable growth have stalled, as have bilateral and multilateral assistance programmes.

Table 1. Gross domestic product in agriculture, total labour force and agricultural output per active person, 1980 and 1988

(Gross product in billions of 1980 U.S. dollars and labour force in millions)

Region	1980			1988		
	GDP in agriculture a/	Total labour force	Agricultural output per worker	GDP in agriculture a/	Total labour force	Agricultural output per worker
Developing countries	320.8	825.0	389	407.2	997.6	408
Latin America	72.7	118.5	614	90.5	144.8	625
Mediterranean	20.9	29.1	718	25.9	34.4	753
North Africa	11.7	23.8	492	15.0	30.4	493
Sub-Saharan Africa	60.5	156.6	386	69.4	189.6	366
West Asia	23.5	23.7	992	35.1	32.2	1 090
South and South-East Asia	131.5	473.3	278	171.3	566.2	303

Source: Office for Development Research and Policy Analysis of the United Nations Secretariat, based on: Statistical Office of the United Nations, Yearbook of National Accounts Statistics and Monthly Bulletin of Statistics (various issues), supplemented by estimates of the United Nations regional commissions, the World Bank, the International Monetary Fund, Organization for Economic Cooperation for Development and other national and international sources; and International Labour Organisation, Labour Force Estimates and Projects, 1988 (Geneva, 1989).

a/ Measured in 1980 prices and exchange rates.

4. Poverty is not conducive to either economic or energy development. Short-term, survival imperatives have already led to serious deforestation in many rural areas of the developing world at a time when population growth continues unabated. It is estimated that 2 billion people, or half of the developing world, have no access to electricity on the eve of the twenty-first century. Their access to other commercial sources of energy is also severely limited. Most of these people are in rural areas, and their number is expected to grow. Unless economic growth resumes in the developing world, national Governments will find it more difficult to redirect resources to rural areas at a time when increasing problems in urban areas also will demand urgent attention. Progress made in the application of new and renewable sources of energy in developing countries should be seen from this perspective.

5. Despite these impediments and the absence of technological breakthroughs, the review presented in this report shows that considerable progress has been made in decentralized systems of new and renewable sources of energy. However, much of the progress has been due to governmental intervention, as in China and India, and has often included considerable subsidies. Despite the current view that such policies may not be either feasible or appropriate in other developing countries, it should be recalled that similar policies and measures are also quite prevalent in the developed countries: they also have found it necessary to promote rural energy supplies in order to achieve more equitable national development patterns.

6. Centralized new and renewable energy systems have been much more successfully applied, particularly with regard to large-scale hydropower projects. In view of increasing environmental concerns, new energy development plans in at least some developed countries (e.g., Denmark, Japan, Netherlands) have recently indicated renewed emphasis on medium- and large-scale developments of solar energy and wind power. Technological advances and cost reduction in these plans could ultimately benefit the developing countries as well through access to appropriate technology and transfer policies. Yet the main energy problem of the developing world in providing decentralized systems to the rural areas would still remain unresolved. Global environmental concerns might, however, provide a significant impetus to new programmes of assistance and financial help for the development and use of both conventional and new and renewable sources of energy. The deliberations of the United Nations Conference on Environment and Development in June 1992 should provide an indication of prospects in this respect.

I. CONTRIBUTION OF NEW AND RENEWABLE SOURCES OF ENERGY TO DECENTRALIZED SYSTEMS

A. Solar

7. One of the most successful applications of solar energy consists of solar thermal systems for low-to-medium temperature, used mainly for domestic water heating, including swimming pools. Thousands of units have been installed in

many developed and developing countries, as shown in the annex (which, unfortunately, is not comprehensive). This application of solar energy presupposes a certain standard of living, particularly with regard to housing which would allow for the necessary capital investments for the necessary equipment and structures. In many developing countries, however, incomes and housing standards are low. However, the introduction of solar water heaters had led to measures for cutting down capital costs through simple designs and the use of local materials and manufacturing.

8. Some developing countries - notably, China, Egypt and India - have plans for widespread use of solar water heaters through the necessary infrastructural, institutional, system and market development. Other successful applications of solar energy include crop, and timber-drying, water desalination and greenhouses. However, the magnitude of these applications is difficult to estimate. A similar situation obtains with passive solar energy systems for the heating and cooling of dwellings. Innovative financing schemes have proved successful in some cases, as have user cooperatives in Bolivia, the Dominican Republic, the Philippines and Peru.

9. Photovoltaic (PV) energy is used all over the world for lighting and power supply for rural and remote areas, pumping, refrigeration, desalination, water purification, portable medical refrigeration, sterilization, communication applications such as radio repeaters, buoys, weather measuring, mobile radios, and river-level and seismograph measuring. Its main advantages for decentralized applications are ease of use, reliability, modular nature, competitive economics for remote sites, well demonstrated technology, and relatively benign environmental impact. The largest market is for remote locations, where photovoltaic systems are competitive. The commercial market of photovoltaic systems is dominated by telecommunication applications. Of the number of photovoltaic units installed, lighting claims the largest share.

10. In developing countries the installations are mainly in domestic or community buildings such as schools and health centres, while in developed countries they are used for security, street and tunnel lighting. More than 10,000 solar pumps are in operation around the world, and experience with them has been good. About 2,000 solar vaccine refrigeration units have been installed in the past five years. 4/

11. The market for photovoltaic modules has been growing steadily over the years: 26 MW in 1986, 28 MW in 1987, 35 MW in 1988, 42 MW in 1989 and 46.5 MW in 1990. The estimate for 1991 is 58-62 MW, and forecasts for 1995 and 2000 are 130 MW and 400 MW, respectively. Of the 46.5 MW photovoltaic modules produced in 1990, about 75 per cent were for such applications as telecommunication, lighting, and pumping, spread over 35 countries; the rest were for the production of consumer goods such as calculators. 5/ The largest producer of the modules in 1990 was Japan (16.8 MW), followed by the USA (14.8 MW) and Europe (10.2 MW). Other countries (mainly, Algeria, Brazil, India) accounted for 4.9 MW.

12. A major obstacle to photovoltaic systems is their cost, which has been estimated at from three to five times higher than that of conventional energy sources. A drastic reduction in the cost of photovoltaic systems will be necessary if they are to have widespread application. If past cost trends continue without interruption, this may be possible in the next 10-15 years.

B. Wind

13. The main applications (see table 2) are small wind electric systems for use in maintaining an adequate level of charge in an electrical storage battery. The battery, in turn, can provide electricity on demand for electrical applications such as lights, radios, telecommunications or electric livestock fencing. Small wind battery charging systems are most commonly rated at 25-100 W in a 10 m/s wind speed, and are quite small, with a rotor diameter of 50 cm to 1 m. Such machines are in relatively large-scale production - notably, in China, the United Kingdom and the United States of America. Around 100,000 such systems are in use today, and annual production is in the range of 10,000-20,000 units per annum.

14. The main use in the developed countries is for lighting and powering small electronic devices in remote buildings, caravans (i.e., residential trailers), yachts and other small leisure vessels. They are being taken up in developing countries for remote settlements, especially in China and Mongolia, where nomadic herdsmen use them for lighting and powering radios.

15. Larger wind electricity generators which can be used for independent applications, including battery charging, also exist. Typical sizes are 250 W, 500 W and 1 kW; the largest that can be considered for battery charging is generally around 10 kW.

16. Wind-diesel systems are finding increased use as a means of reducing electricity unit costs and diesel operating hours. Firm figures on world-wide use are, however, unavailable. Wind-diesel systems can range in size from 10-15 kW to several megawatts combined capacity.

17. The main applications for wind pumps are in arid regions where they are used to provide essential water for drinking and crop irrigation. Irrigation is a seasonal requirement, often needed for only two or three months of the year, and it tends to use surface water or water from shallow water sources. Hence a wind pump for irrigation commonly needs to earn a whole year's return on the investment in only a few months. Windmills are generally much better suited to supplying drinking water where the value of the product is relatively high.

18. Specialized, inexpensive traditional designs of windmills for low-head, high-volume pumping are used for irrigation pumping in Thailand and China. In India the National Wind Energy Programme covers all aspects of both wind electricity generation and wind pumping systems. It includes projects for research and development, installations and demonstrations, field testing, commercialization and international cooperation.

19. China has focused its attention on wind energy exploitation in remote and non-grid connected regions. In recent years, around $1 million has been invested annually to develop wind energy. There are about 60 institutions and manufacturers engaged in the development and production of wind turbines, and more than 80 types of wind machines, up to 20 kW in capacity, have been developed. In Inner Mongolia 40,000 mini-aerogenerators of 50-100 W are in use. Table 3 below provides information on selected countries.

Table 2. Wind power applications and status

System	Application	Status
Battery charging	Boat/caravan lights	Commercial
	Electric fences	Commercial
	Expeditions	Commercial
	Navigation aids	Experimental
	Telecommunications	Experimental
Grid connected	Supplementing mains supply	Experimental
Wind-diesel	Remote settlements	Experimental
	Irrigation pumping	Experimental
	Sea water desalination	Experimental
Windpumps (mechanical)	Drinking water supply	Commercial
	Irrigation pumping	Commercial
	Dewatering	Commercial
	Sea-salt production	Commercial
	Desalination by reverse osmosis	Experimental
Miscellaneous	Ice production	Experimental
	Cooling/air conditioning	Experimental
	Heating	Experimental
	Milling grain etc.	Historical

Source: P. Fraenkel and F. Crick, "Wind energy: technology and resource", paper prepared for the New and Renewable Sources of Energy Section, Energy and Resources Branch, Department of International Economic and Social Affairs, and submitted to the meeting of the Intergovernmental Group of Experts on New and Renewable Sources of Energy, August 1991.

Table 3. National or state wind energy programmes and installed capacity

Country/state	Wind energy programme	Turbines installed	Installed capacity (MW)
California (USA)	10 per cent of electricity supply by year 2000	15 000	1 400
Denmark	200 MW for utility by 1993, 10 per cent of electricity supply by the year 2000	2 000	190
Holland	150 MW by 1991 1 000 MW by year 2000	..	40
Italy	300 MW by year 2000	..	2
Germany	200 MW (no time specified)	..	10
Spain	90 MW by 1993	68	5.3
India	5 000 MW by year 2000	250+	35
Greece	400 MW by year 2000	15+	2

Source: M. Rand and A. Clarke, Wind Engineering (February 1991).

C. Biomass

20. Traditionally biomass has been used as fuel, especially where fuelwood is relatively scarce. The most popular materials for this application are crop residues and animal dung. The most widespread use is in the densely populated plains of northern India, Bangladesh and China. Here, dung and crop residues are the major domestic fuels, providing as much as 90 per cent of household energy in many villages and a considerable proportion in urban areas too. Dung and crop residues provided 23 per cent of the entire energy consumption of India in 1979. Since then, the residues have found newer uses as energy sources for industries and have been increasingly commercialized. Forty-five per cent of the rural energy needs of China were met by straw and crop stalks in 1983. Residues are also burnt in many parts of Africa, South-East Asia and Latin America, although to a much lesser extent.

21. Crop residues provided as much as a third of the total energy consumed in Egypt and animal dung a further 10 per cent, and crop residues and dung provided 58 per cent of the national energy needs of Ethiopia, where in some

towns as much as 90 per cent of total household cooking was reportedly done with dung. It has also been estimated that crop residues provided 3 per cent of national energy use in Kenya, while up to 30 per cent of the national energy needs of Lesotho was met by dung.

22. Alternative uses of biomass depend on the type of material. Animal dung is, for example, also used as fertilizer, building material, insect repellant and pesticide. Many crop residues are ploughed back into the soil as fertilizer and organic matter. They are also used as fodder - the best materials being those that are high in protein and easily digestible, like most green plant residues, residues of pulse crops and groundnuts. Other materials, like jute sticks, palm residues and cotton stalks, are used as building materials and for handicrafts. Rice husks and sawdust are generally little utilized and sometimes constitute a disposal problem. Excess cotton stalks in the field are also a disposal problem in a number of countries.

23. In the traditional sector, a main constraint to the use of biomass is availability, which is in turn affected by production levels, seasonality and a range of socio-economic factors - for example, land and animal ownership and the status of a family - which affect access to residues such as dung.

D. Fuelwood

24. The impact of the wide variety of actions, projects and activities undertaken to improve the wood energy situation in developing countries has been insufficient for the magnitude and the importance of the problems involved. Fuelwood and charcoal are and will remain for decades to come major sources of energy for decentralized applications in developing countries. The development of efficient cooking stoves for household use and improved techniques for charcoal-making have also been given considerable attention.

25. In many countries, fuelwood makes up a high proportion of total energy used; for example, 32 per cent in India, 30 per cent in Thailand, and 40 per cent in the Philippines. Even in net oil-exporting countries, fuelwood makes up a significant proportion of the total energy used: in Bolivia, 42 per cent; Indonesia, 34 per cent; Nigeria, 59 per cent, and Peru, 26 per cent. Fuelwood production by developing countries was over 80 per cent of the total world supply throughout the 1980s.

26. In sub-Saharan Africa there is almost total dependence on fuelwood by the rural households, but in other developing regions other biomass resources contribute substantially. Demand for fuelwood is usually lower in the urban areas of developing countries than in the rural areas. One of the main reasons is the availability of other fuels, such as charcoal and fossil fuels, and access to electricity. Improved charcoal-making techniques are a viable option for reducing fuel consumption in both rural and urban areas. Charcoal briquettes, made from charcoal fines, and biomass are gaining in use.

27. Considerable efforts have been made to develop and market new, more efficient woodstoves to substitute for the traditional and widespread three-stone open fire. Modern woodstoves, although energy efficient, require outlays from very poor households and changes in social habits and long-term practices. As a result, the increase in the use of modern woodstoves has been painfully slow, and the limited success has been confined mainly to urban areas and has often required governmental support and incentives.

28. The fuelwood problem in the developing world is not caused by energy use alone. Vast forest and other wooded areas have been cleared in order to expand agricultural land for the food needs of a growing population. Reforestation or replanting of trees is an expensive and long-term proposition which can hardly be expected to materialize in the midst of poverty and the existing land ownership patterns without outside support and assistance. In Indonesia, for example, plans call for an investment of $300 million for replanting 300,000 hectares per annum, $1,000 per hectare. 6/

E. Hydropower

29. Small-scale (up to 5 MW) hydropower capacity in the world has been estimated at 25,300 MW. Plants under construction will add another 500 MW, and 5,230 MW are planned for development in 71 countries, mostly in Asia, Europe and Latin America. More than 500 companies now produce equipment for the small hydro market. 7/ About half of the small-scale hydro capacity is in the developed countries, with the other half in the developing world where, however, China has 9,500 MW.

30. There is a vast potential for small-scale hydro in developing countries, although detailed assessments are scarce. While operating costs are minimal, quite often capital costs are significantly higher than those for diesel power plants which, of course, have higher running cost because of the fuel input. In one investigation by the Department of Technical Cooperation for Development of the United Nations Secretariat involving 150 small-scale power sites in many developing countries, it was found that the spread of estimated capital cost ranged from $1,865 to $5,770 per kW installed, with an average of about $2,850 (1990 dollars). This may be as much as three times the capital cost of diesel power plants.

31. In developing countries, where scarcity of capital, particularly in rural areas, is a given, the heavy investment costs of small-scale hydro are a serious impediment for intensive development even if financial analysis indicated that, over the full life of the plant, hydro would be economical. The civil engineering component of small-scale hydro schemes may account for as much as 60-75 per cent of the overall investment cost. The local civil engineering capacity and a supply of local materials often reduce investment costs. Multilateral, regional and bilateral aid agencies have provided significant financial assistance for small-scale hydro development in developing countries. Such efforts have often been supplemented by local Governments. Yet much more will be required in the future if there is to be widespread development of small-scale hydro in rural areas.

F. Draught animal power

32. Animal traction is currently receiving considerable attention in many countries in Africa and Asia. No accurate figures on the draught animal population are available, but table 4 gives a rough estimate of the possible number, by species, in developing countries, and table 5 gives the dispersion by country. The estimated increase in the number of draught animals used in farm work has been projected by the Food and Agriculture Organization of the United Nations to the year 2000, as in table 6.

Table 4. Domesticated animal population, by species

(Millions)

Specie	Milk + meat + draught			Draught animals in developing countries (estimated)
	World	Developed	Developing	
Cattle and yak	1 212.0	425.0	787.0	246
Buffalo	130.6	0.9	129.7	60
Horse	61.8	22.4	39.4	27
Mule	11.6	0.7	10.9	10
Donkey	42.8	2.0	40.8	40
Camel	16.8	0.2	16.6	16
Llama	1.4	--	1.4	1
Elephant	--	--	--	-- a/
Total	1 477.0	451.2	1 025.8	400

Source: "Draught animal power as a source of renewable energy", paper prepared for FAO by N. S. Ramasuamy, January 1981.

a/ There may be about 20,000 elephants engaged in logging and packing work.

Table 5. Estimated livestock dispersion, by country

(Millions)

Country	Cattle	Buffaloes	Horses	Mules	Donkeys	Camels
India a/	110.0	16.0	1.0	0.1	1.0	1.7
China a/	53.0	17.0	11.0	4.0	7.4	1.1 b/
Bangladesh	10.0	1.0	--	--	--	--
Thailand	3.0	5.0	--	--	--	--
Pakistan	7.0	0.5	0.5	0.1	2.3	0.8
Ethiopia	6.0	--	1.5	1.4	3.9	1.0
Indonesia	3.5	2.0	--	--	--	--
Burma	4.0	1.0	--	--	--	--
Nepal	2.8	2.0	--	--	--	--
Philippines	0.6	3.0	0.3	--	--	--
Mexico	2.8	--	6.5	3.2	3.2	--
Brazil	2.6	N.A.	2.0	1.7	1.7	--
Turkey	2.5	--	0.6	0.3	1.4	--
Colombia	1.3	--	1.0	0.6	0.6	--
United Republic of Tanzania	1.0	--	--	--	0.2	--
Egypt	1.0	N.A.	--	--	--	--
Chile	0.3	--	0.5	--	--	--
Peru	0.1	--	0.4	0.2	0.5	1.2 c/

Source: "Draught animal power as a source of renewable energy", paper prepared for FAO by N. R. Ramasuamy, January 1981.

Note: Some of the figures are from sources other than FAO.

a/ Including young stock.

b/ Including yaks.

c/ Llamas.

Table 6. Draught animals in farm work, 1975 and 2000

(Thousands)

Country	1975	2000 (projected)	Difference
India	82 295	92 957	+10 662
China	50 000	..	..
Bangladesh	10 000	17 245	+7 245
Brazil	8 852	8 722	-130
Pakistan	8 000	5 518	-2 482
Indonesia	5 616	7 630	+2 014
Ethiopia	5 000	5 460	+460
Thailand	4 000	5 784	+1 784
Philippines	3 593	4 492	+899
Mexico	3 000	2 561	-439
Burma	2 937	3 799	+862
Turkey	2 500	1 500	+1 000
Viet Nam	2 098	2 303	-205
Morocco	1 530	1 211	-319
Colombia	1 300	1 400	+100
Nepal	1 200	1 392	+192
United Republic of Tanzania	1 048	1 640	+282
Madagascar	1 000	1 640	+640
Egypt	1 000	807	-193
Sudan	1 000	1 200	+200
Afghanistan	1 000	1 170	+170
Iran (Islamic Republic of)	1 000	684	+316
Cambodia	1 000	1 280	+280
Argentina	961	649	-312
Nigeria	949	1 386	+437
Kenya	800	1 016	+216
Republic of Korea	716	1 088	+372

Source: "Draught animal power as a source of renewable energy", paper prepared for FAO by N. S. Ramasuamy, January 1981.

II. CONTRIBUTION OF NEW AND RENEWABLE SOURCES OF ENERGY TO SPECIFIC MULTI-PURPOSE MEDIUM- TO LARGE-SCALE APPLICATIONS

33. The contribution of hydropower, geothermal and to some extent oil shale and tar sands to the category of multi-purpose medium-scale and large-scale uses is substantial. Large-scale wind energy applications are considerable and, in some cases, competitive with conventional energy sources. The contribution of solar thermodynamic and photovoltaic energy is still very small, but development efforts are focused on medium- to large-scale grid-connected applications. It is expected that the contribution of solar, photovoltaics and wind will increase in the future because of technological advances and environmental policies.

A. Solar

34. Large-scale use of solar thermal energy essentially relates to the conversion of solar thermodynamic energy into mechanical energy which may be further converted into electricity. Examples are found mainly in the United States of America. The process can also be used for pumping water; but it has not been competitive with photovoltaic-powered pumping systems or with conventional sources of energy. 4/

35. A 1-MW plant for electricity generation has been operating for a long time at a site in Sicily. Development work, mainly in the United States, has reduced the cost of producing electricity by this method by as much as 80 per cent in the past 10 years. Nine plants generating a total of 354 MW, have been installed for a utility company in southern California. The largest of the plants has a rated capacity of 80 MW. Newer plants produce electricity at $0.08/kWh. Plans are under way for using a similar technology in Brazil and India. World-wide grid-connected photovoltaic systems are about 33.6 MW, distributed as follows: Austria (60 kW), Belgium (63 kW), Germany (990 kW), Greece (150 kW), Ireland (50 kW), Italy (5,500 kW), Japan (1,000 kW), France (100 kW), Netherlands (50 kW), Spain (200 kW), Switzerland (610 kW), and the United States (25,000 kW). The largest systems are rated at 5 MW in California (United States) and 3 MW in Naples (Italy). 4/

B. Wind

36. The impetus of wind turbine development began in Denmark and California during the early to mid-1980s as fiscal incentives to encourage wind electricity generation were legislated in both areas. In the distribution of wind turbines installed in grid connection applications world wide, California (USA) still dominates in terms of sheer numbers, (see table 7) but wind farms are beginning to be developed in numerous other countries, including the Netherlands, Germany, Spain, the United Kingdom, Belgium, Finland, Greece, Italy and India. Japan is also becoming a major supplier of wind turbines for wind farms.

Table 7. Status of California wind farms, 1990

	Amount/size
Total number of turbines installed	15 114
Total capacity installed	1 398 MW
Total investment	$2 600 million
Total land area used	2 300 ha
Annual energy production	2 124 GWh
Annual income from wind farms	$159 million
Expected number of machines to be installed in 1990	1 175
Expected capacity to be added in 1990	190 MW
Average new turbine size in 1990	180 kW

Source: P. Fraenkel and F. Crick, "Wind energy: technology and resource", paper prepared for the meeting of the Intergovernmental Group of Experts on New and Renewable Sources of Energy, August 1991.

37. Large-scale wind turbines and wind farms are not generally associated with development-assistance projects. In fact, the only wind farms so far to be established in a developing country are in India, although the Cape Verde Islands have a small wind-turbine installation connected to the local grid provided under Danish bilateral assistance.

38. In developed countries emphasis has been placed on the use of wind energy for electricity generation, usually integrated into existing grid networks to take account of its intermittent character. The technology must be improved to reduce costs, and awareness of the environmental benefits needs to be increased. This is being accomplished by national programmes initiated by Governments which increasingly accept the role of wind energy in a system of sustainable energy supply for the future.

39. For example, in Denmark the wind power programme for the development of large-scale turbines is sponsored jointly by the Government and the electric utilities. Small-scale wind turbines were promoted by public subsidies offered to private owners of wind turbines. In addition the Danish electric utilities and the Ministry of Energy agreed in 1985 to instal 100 MW in land-based wind farms, and a 5-MW off-shore wind farm is planned. Swedish wind-power activities include demonstration projects such as off-shore wind-farm installations. The wind-energy industry in the Netherlands may increase dramatically in the future. During the period 1987-1990, the installed wind-power capacity rose from 15 MW to 45 MW in operation and 35 MW under construction. The Government target is 1,000 MW for the year 2000 and 2,000 MW by 2010, including some off-shore sites.

C. Biomass

40. Biomass is being used for energy generation in industries, especially in the agro-industrial plants, for on-site use, to supply the national grid or for rural electrification. Around the world, most of the industrial use of biomass for fuel is at biomass-processing mills which use their own residues. The chief constraint for the industrial use of biomasss in industrial countries is the unfavorable economics of biomass production and utilization in the face of relatively low energy prices - in particular, those of oil.

41. In a number of countries - notably, Brazil, Kenya, the Philippines, the United States and Zimbabwe - alcohol from biomass conversion is being used extensively in the transport sector, often blended with conventional gasoline; and 10-20 per cent alcohol fuels are widely used. In Brazil higher levels of alcohol in the blended fuels are in use; in many cases, engine designs have been changed to use up to 100 per cent alcohol. However, costs for alcohol blends are considerably higher than for oil at current prices.

D. Fuelwood

42. In industrial countries the use of biomass - in particular, of fuelwood - is being encouraged as a renewable energy source for future larger-scale applications, particularly because of the much lower emissions of pollutants from such materials relative to those from fossil fuels. Biomass materials contain little sulphur and so cause little sulphur emission. They emit carbon dioxide (CO_2) when burned but also recapture large quantities of CO_2 during their growing period.

43. Fuelwood, in particular, and charcoal have traditionally been used in rural industries throughout the developing world. They can be classified into three categories of industry: cottage, village, and rural. These industries produce a wide range of materials such as food, herbs and spices, drinks and beverages, other agricultural materials (such as tobacco), wood, metal, bricks, tiles, pottery, lime, soap and dyes. Charcoal is used in industry for metallurgical purposes and cement manufacture in Brazil because of its extensive forests.

44. Gasification of wood for generation is, as a general rule, not economically competitive at current energy prices. The same is mainly true for steam-based power generation, the other alternative for making electricity out of fuelwood and charcoal. There are, of course, specific locations, with either very cheap fuelwood or very expensive petroleum fuels, where steam or gasification may be competitive.

E. Hydropower

45. Large-scale hydropower is by far the largest commercial renewable source of energy in both developed and developing countries. In 1989, hydropower supplied 15 per cent of the electricity generated in the developed countries and 30 per cent of that in the developing world. Only a quarter of the net exploitable potential has been developed in the industrial world and only 10 per cent in the developing countries (see table 8); thus, large resources considered exploitable under current technical and economic conditions are available for future use.

Table 8. Exploitable and exploited hydro resources, 1989

Area	Net exploitable (TWh)	Exploited (TWh)	Exploited as percentage of exploitable	Exploited as percentage of all power sources
World	12 600	2 094	16.6	18.3
North America	820	598	72.9	16.3
South America	2 860	327	11.4	76.2
Europe	740	465	62.8	16.9
USSR	3 220	224	7.0	13.0
Africa	1 080	44	4.1	14.4
Asia	3 700	398	10.8	16.8
Oceania	180	38	21.1	21.0
Industrialized countries	5 160 (41%)	1 382	26.8	15.3
Developing countries	7 440 (59%)	712	9.6	30.1

Source: K. Goldsmith, "Hydropower", paper prepared for the meeting of the Intergovernmental Group of Experts on New and Renewable Sources of Energy, August 1991.

46. Electricity continues to be the preferred form of energy consumption because of its versatility in use in most economic sectors. As a result, the share of electricity in commercial primary energy consumption has been growing throughout the world. 8/ In the developing countries electricity consumption has been growing at an average annual rate of 7 per cent, which implies a need for the doubling of capacities every 10 years. For the 1989-1999 period, the World Bank has estimated that 36 per cent of all additional generating capacity in the developing world will be based on hydropower at a total investment cost of $260 billion (1990 United States dollars) or an average of $1,850 per kW for medium and large hydro plants. 9/

47. Hydropower expansion in the developed countries is hindered by environmental problems and long-term siting delays. The developing countries are faced with further difficulties - in particular, deep indebtedness, the high cost of capital, when available and inadequate regional and interregional cooperation which might facilitate the application of modern transmission technologies to distant markets. Nevertheless, the pollution-free characteristic of large-scale hydropower has already led to a variety of expansion plans in a few regions of the developing world. Similarly, new arrangements such as BOT (build/operate/transfer) are already making a contribution to new projects in some developing countries.

F. Geothermal energy

48. Considerable progress has been made in the spread of geothermal electricity in both developed and developing countries (see table 9). The United States - mostly in California - has retained its premier position in this field, with 2,800 MW in 1990 as compared to 950 MW in 1980; another 400 kW are expected to be added by 1995. Considerable additions are also expected in Italy, Japan and New Zealand. By 1995, total installed capacity in the industrial world (Greece, Iceland, Italy, Japan, New Zealand, Portugal (Azores), United States and USSR) is expected to reach 4,922 MW, from 1,755 MW in 1980.

Table 9. Geothermal electric power

	1980		1990		1995 (estimate)	
	Number of countries	MW	Number of countries	MW	Number of countries	MW
Developed	7	1 755	8	3 916	8	4 922
Developing	6	728	10	1 959	15	4 128
Total	13	2 483	18	5 875	23	9 050

Source: G. M. DiPaola, "Geothermal energy development", a background report prepared for the meeting of the Intergovernmental Group of Experts on New and Renewable Sources of Energy, August 1991.

49. Progress in the developing world has been more impressive. The number of developing countries with geothermal electricity will increase by 1995 to 15 from six in 1980, with installed capacity going up to 4,128 MW, from 728 MW. Among the developing countries (Bolivia, China, Costa Rica, Djibouti,

El Salvador, Guadeloupe, Guatemala, Indonesia, Kenya, Mexico, Nicaragua, Philippines, Romania, St. Lucia, Turkey), by far the most important expansion is expected in the Philippines (446 MW (1980), 894 MW (1990) and 2,164 MW (1995)). Considerable expansions are also expected in Costa Rica, El Salvador, Indonesia, Kenya, Mexico and Nicaragua.

50. By 1990, geothermal power was already making a significant contribution to the electricity needs of certain developing countries - e.g., 15 per cent in the Philippines, 14.6 per cent in El Salvador, 6.1 per cent in Kenya and 3.2 per cent in Indonesia. The resource potential is considerable in several of the developing countries already mentioned as well as in others where investigations have been carried out.

51. The lack of financial resources and the risk involved in geothermal investigations, particularly exploration drilling, continue to be important impediments for expansion in many developing countries. The success of the Philippines may largely be attributed to its success in attracting foreign risk capital and investments through long-term agreements, with acceptable pricing clauses for discoveries.

52. Considerable progress has also been made in the utilization of low-enthalpy geothermal energy for process heat. By 1990, a total of 11,374 MW (equivalent) was being used in 17 developed countries (8,485 MW) and nine developing countries (2,916 MW). The largest users are Japan (3,321 MW), China (2,143 MW), Hungary (1,276 MW), USSR (1,133 MW) and United States (463 MW). Smaller capacities were in use in Algeria, Australia, Austria, Belgium, Canada, Colombia, Czechoslovakia, Denmark, Ethiopia, France, Germany, Greece, Guatemala, Iceland, Italy, Mexico, New Zealand, Poland, Romania, Switzerland, Thailand, Tunisia, Turkey and Yugoslavia.

G. Ocean energy

53. Of the ocean energy resources, only tidal energy is applied on a large scale at the moment. At La Rance in France one plant of 240 MW has been operating since 1968. In Canada, at Annapolis, a plant of 20 MW, is operating as is a 10-MW plant in Jianxia, China, and a 400-kW plant in Kislaya Guba, USSR. There are no large-scale wave plants now operating. However, there are several demonstration plants in Denmark, China, India, Ireland, Japan, Norway, Portugal, Puerto Rico, Sweden and the United Kingdom. The largest is a 350-kW plant in Norway. A 150-kW plant is being built in India. 10/ Plants of up to several hundred kilowatts are currently planned or under construction in China, Denmark, India, Japan, Norway, Portugal and Scotland. 11/ The only on-line OTEC plant currently in operation is a closed cycle 25 kW in the Kagashima Prefecture in Japan.

H. Peat

54. The primary use of fuel peat in the developed countries is for electrical power generation, both in condensing plants and in cogenerating plants producing heat and power. The most important users are large municipal power and heating plants, industrial power and heating plants, district heating plants, and building heating plants.

55. At present the annual production of peat in the Soviet Union is about 80 million tons. In 1990, 4 per cent of Finland's total energy was provided by fuel peat. Milled peat is the most important product (1990 production: 14 TWh) and is used mainly for combined heat and power. About 10 per cent (2 TWh) of the fuel peat is sod peat, which is used partly as fuel and partly as a raw material for ammonium fertilizer.

56. In Ireland, peat is mainly used for electricity generation. In Sweden, as of 1986, the sod peat production amounted to 1.4 TWh and milled peat to 0.9 TWh. Peat consumption in 1989 was 1.95 TWh. In North America, restrictions on local production and complicated laws decreased interest. In many tropical developing countries most peat projects are still at an early phase of development; fewer than 10 projects have reached the commercial stage. Commercial activities have been started on a joint venture basis in Malaysia.

57. Peat has possible non-energy applications in the cement industry, heavy clay industry (e.g., firing of bricks), glass industry and in the metallurgical processes. In the USSR the peat industry is undergoing a structural change, with a considerable increase in production for agricultural use, which now exceeds 55 million tons per year. Horticultural peat is produced by several small enterprises in the United States, mostly by using European production technologies. There is growing interest and potential in many tropical countries in developing peat for agriculture, forestry, energy, horticulture and as raw material for many industrial products.

I. Tar sands

58. Canada accounts for about 75 per cent of the world's tar sand resources, followed by the USSR (22 per cent). The remaining 3 per cent is distributed among 18 other countries, including Angola, Brazil, Chile, Côte d'Ivoire and Nigeria. At present the only significant commercial production of energy fuel from tar sands is in Canada. It involves upgrading the bitumen extracted from the tar sands to synthetic crude oil at integrated mining facilities in Alberta. The amount of synthetic crude produced is about 200,000 barrels per day.

59. In Venezuela, tar sands are being commercially exploited with a new method producing Orimulsion, a liquid emulsion consisting of 70 per cent bitumen, 30 per cent water and a surfactant. Orimulsion has undergone successful industrial tests as a substitute for coal in thermoelectric power

plants and is being marketed commercially. Supply from this source may reach 1 million barrels per day by the year 2000. In several countries natural asphalt and bitumen are being mined for non-energy industrial use, and bitumen continues to be used widely as paving asphalt for road construction.

60. The cost of oil production in Canada from tar sands has been quite high, and expansion plans have been scaled down. Horizontal drilling and new technologies, however, may result in lower costs. Developing countries with tar sand deposits should be encouraged to survey and evaluate their resources for future development.

J. Oil shale

61. Oil shale resources are widespread in both developed and developing countries. Their potential production has been compared to all the world's reserves of conventional oil. 12/ Their utilization has, however, been limited. The only exception is in Estonia where about 3,000 MW of electricity are derived from oil shale.

62. Limited quantities of shale oil are produced in China (about 6,000 barrels per day), and in Brazil a pilot project in operation since 1972 is producing 850 barrels per day. A new commercial plant in Brazil will be operational in 1992 when total shale-oil production in that country is expected to reach 3,870 barrels per day. In the United States, an oil shale demonstration plant in Colorado has been operated by an oil company with subsidies of $40 per barrel of shale oil and an average production of about 6,000 barrels per day. Yet the plant was closed down in mid-1991 because of financial losses. 13/ Other countries are known to have active oil-shale research and development programmes (e.g., Israel, Jordan, Morocco, Yugoslavia). Because of high capital and operating costs, the widespread use of oil shale resources in the foreseeable future is unlikely unless technological breakthroughs can be achieved, especially in the mining of the deposits.

III. CONCLUSIONS AND PROPOSALS FOR ACTION

63. Progress in new and renewable sources of energy during the 1980s fell far short of expectations. However, energy prices since the mid-1980s, a growing realization of the plentiful availability of conventional energy resources and reserves, economic development policies and beliefs favouring free markets, less governmental intervention and a deep recession and indebtedness in most of the developing countries have contributed to sizeable reductions in research and development as well as in investments in new and renewable sources of energy.

64. Short-term economic survival became the order of the day amid growing poverty. Medium- and long-term development prospects were postponed. Conventional energy shortages in more than 30 developing countries further

retarded economic growth. Deforestation continued unabated and a fuelwood crisis imposed even more burdens on the most vulnerable social groups of the rural population.

65. The promise of new and renewable sources of energy became a substitute for actual energy supplies. A few modern wind systems and photovoltaic panels, contributed through generous donations from the bilateral assistance programmes of the industrial world and supported by non-governmental organizations and multilateral agencies, were visible aspects of the promise. But their costs were often two, three and five times the cost of conventional energy alternatives which, in any case, were not affordable by the rural population whose meagre earnings of $0.5-3.00 per day had to be spent on so many other pressing priorities such as shelter, food and water.

66. Yet amid the gloom, there were some bright spots. Considerable progress was made in China in mini-hydro, biogas plants, the use of agricultural residues and even in geothermal energy. India's experience was similar. Other developing countries with well considered plans also had positive results. Perhaps free-market forces were not the only answer. Appropriate governmental intervention and incentives for private enterprise might be another way. Such policies were successful in the industrial world as well, as demonstrated by California in the United States. More recently, similar policies in, for example, Denmark and the Netherlands promise well for wind power and in Japan, for photovoltaics.

67. Growing environmental concerns, particularly global climate warming, have already led to a new awareness of the energy problems of the developing world. However, much more needs to be done to concentrate world attention on the need for economic development especially in the rural areas of the developing world, which can only be achieved through equitable national policies and massive support from the international community. Cost-effective technological developments in new and renewable sources of energy in the industrial world can be transferred effectively to the developing countries, both through more financial resources from bilateral and multilateral assistance programmes and incentives for private enterprise investments.

68. In recognizing the magnitude of the energy problem of the developing countries, particularly with regard to decentralized energy systems for rural areas, the Committee may wish to outline an urgent programme of action which could include national evaluation studies during 1993-1994, a global consultative meeting in 1995 in order to assess the support of the international community, and re-examination of this crucial issue at its eighth session in 1996.

Notes

1/ Official Records of the General Assembly, Forty-Fifth Session, Supplement No. 36, (A/45/36).

2/ See Report of the United Nations Conference on New and Renewable Sources of Energy, Nairobi, 10-21 August 1981 (United Nations publication, Sales No. E.81.I.24), chap. I, sect. A.

3/ See A/AC.218/1992/9.

4/ See B. McNelis and F. Crick, "Solar energy: technology and resources, paper prepared for the meeting of the United Nations Intergovernmental Group of Experts on New and Renewable Sources of Energy" (New York, August 1991).

5/ Informal conversations with Mr. Paul Maycock, based on the report "Photovoltaic technology, performance, cost and markets: Forecast to 2010", published by Photovoltaic Energy Systems, P.O. Box 290, Cassanova, Virginia, USA.

6/ Subsoto, "Towards harmonization of sustainable development and the environment", Viewpoint (Vienna, Organization of Petroleum-Exporting Countries 1990).

7/ Eric Wilson, "Small-scale hydroelectricity", Energy Policy (October 1991).

8/ United Nations, World Economic Survey, 1989, Sales No. E.89.II.C.1, chap. V.

9/ K. Goldsmith, "Hydropower", paper presented at the meeting of the United Nations Intergovernmental Group of Experts on New and Renewable Sources of Energy (New York, August 1991).

10/ "Ocean energy", (NPSE/IGM/BP/8).

11/ J. Falnes and J. Sorseth, "Ocean wave energy", Energy Policy, vol. 19, No. 8 (October 1991).

12/ United Nations Utilization of Oil Shale, Progress and Prospects, Sales No. 67.II.B.20.

13/ DIESA, "Tar sands and oil shale", paper prepared for the meeting of the United Nations Intergovernmental Group of Experts on New and Renewable Sources of Energy (New York, August 1991).

Annex

SUMMARY OF DECENTRALIZED SOLAR ENERGY APPLICATIONS, BY COUNTRY

(1990, if not otherwise stated)

SWH: Solar water heaters; PV: photovoltaic

Country	Installed area (m^2)	Units installed	Manufacturing or sales/yr.	PV installed	Applications
Africa					
Algeria			2,000 units		Solar water heaters in the Saharan region 30 PV pumps PV-powered village serving 11 houses PV medicine refrigeration Telecommunication in remote areas PV lighting for 670 km road
Egypt		30,000		217 kW	Solar technologies widespread and demonstrated By 1990 30,000 solar water heaters had been installed PV is used for desalination; water pumping for land reclamation; refrigeration; telecommunication; cathodic protection; navigational buoys and alarm systems
Mali					200 PV pumping units installed
Mauritius		5,000			Remote island PV-powered radio communication Demonstration of PV lighting on one island

Country	Installed area (m^2)	Units installed	Manufacturing or sales/yr.	PV installed	Applications
Morocco			500 units		PV fairly widely used for rural electrification, telecommunication, water pumping and medicine refrigeration 200 kW of domestic PV lighting, plans for 2,000 PV pumps
Sudan					125 PV-vaccine refrigerators 12 PV-powered TV sets for schools
Tunisia			8,000 units		30 kW demonstration plant in cooperation with the United States 110 PV systems in 90 rural homes and 7 schools, in cooperation with Germany PV electrification of rural village with 97 houses, in cooperation with Spain
Zaire					100 PV refrigerators and 750 lighting systems in rural health centres and hospitals, with assistance from EEC
Zimbabwe		2,000	150 kW		Solar water heaters for wealthier customers PV used for lighting, refrigeration and pumping in rural areas

Country	Installed area (m^2)	Units installed	Manufacturing or sales/yr.	PV installed	Applications
Asia and the Pacific					
Australia		300,000	30,000	At least 2 MW	Solar water heaters in 5% of all homes PV for navigational beacons, telecommunication relays, water pumps, small number in remote homes Telecommunication represents 2 MW
China	1,800,000 SWH 300,000 passive 11,000 dryers	120,000 cooking units 330,000 ha of solar thermal greenhouses	400,000	1.5 MW	Wide distribution of solar water heaters, passive solar in buildings, solar cookers, solar crop dryers and greenhouses PV cheapest alternative in many locations, rural area use 42% of total installed capacity; telecommunications, 37%, beacons, lighthouses, signals 8%; cathodic protection, 2%; measuring stations (weather, water, earthquakes), 2%; and other, 9% Production capacity 4.5 MW; however, production only 600 kW in 1989

Country	Installed area (m^2)	Units installed	Manufacturing or sales/yr.	PV installed	Applications
India	174,000 SWH				Solar water heaters used mostly for domestic use, some for industrial and other commercial uses All solar thermal application estimated to produce what would correspond to 300 million kWh per year for India Domestic manufacturing of PV modules. Installation rate 1.5 MW in 1990 About 7,000 villages have been installed with PV lighting One third of market is commercialized and non-subsidized
Indonesia		8,000		600 kW	Solar water heaters are used 90% in households, 7% in hotels, 2.2% in hospitals, and 0.9% in sports centres 400 PV units installed for pumping, rural electrification, fish freezing, TV, refrigeration and telecommunication 67 railway signalling units 24 PV-powered satellite receiver stations One PV-powered car for research purposes

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Country	Installed area (m^2)	Units installed	Manufacturing or sales/yr.	PV installed	Applications
Israel		900,000			65% of all households have solar water heaters, 3% of energy consumption is met by solar thermal energy, mainly water heating One village's electricity totally supplied by PV PV used for warning lights, isolated irrigation systems, traffic lights, bus station lighting, telecommunication, military installations and cathodic protection
Japan		1,500,000 (only in Tokyo)			Solar water heaters widely used World's largest PV module producer (16.8 MW, 1990)
Jordan		110,000			Local manufacturing of domestic solar water heaters that are gaining increased use PV is used for: telecommunication for civil defence and police, rural electrification (refrigeration, TV, telephone), train traffic control, power for remote aviation sites and pumping for remote areas

Country	Installed area (m^2)	Units installed	Manufacturing or sales/yr.	PV installed	Applications
Korea, Democratic Republic of				768 kW	Of total installed capacity of PV: telecommunication is 47%, street lighting 22%, lighthouses 14%, rural electrification 35%, research plants 3% and others 10%
Malaysia			5,469 m^2 (sales 1990)	100 kW	Solar water heater sales in 1990 amounted to $4 million; basically commercialized for urban use PV applications still at an infant stage, totalling 100 kW PV is used for electrification for individual houses, rural communication, measuring instruments for irrigation and drainage, street lighting, water pumping and police radar equipment
Philippines				250 units	PV systems installed on small islands
Sri Lanka					PV for lighting, TV and radio for 300 rural households, mainly comparatively rich customers 50 rural community centres and hospitals receive their electricity from PV systems Three villages receive electricity from centralized PV battery charging systems

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Country	Installed area (m^2)	Units installed	Manufacturing or sales/yr.	PV installed	Applications
Thailand					Battery charging systems of 500 W each for a few villages
Turkey					Solar water heaters are extensively used in southern Anatolia PV used for irrigation and lighting
Europe					
Austria	380,000		54,000 m^2 (1989)	25 kW	45% of solar water heaters are used for swimming pools, 55% for domestic hot water. Annual heating output is about 125 GWh. PV systems are used for warning systems in the Alps
Belgium			1,000 m^2(sales 1987)		
Bulgaria	50,000	400			
Cyprus	275,200 (1983)	98,300 (1983)	30,000 m^2 (1990)		In 1983 60% of the population used solar water heaters Solar water heaters replace 9% of electricity consumption today
France			50,000 m^2 (sales 1987)		

Country	Installed area (m^2)	Units installed	Manufacturing or sales/yr.	PV installed	Applications
Germany	420,000			3,000-15,000 kW	Public baths and 420,000 swimming pools are heated with solar collectors 2,250 PV units, of 1-5 kW each, installed in old federated states, 750 in the new federated states
Greece	1,500,000			140 kW	Most extensive solar water heater installation in Europe 200 lighthouses are PV-powered Demonstration projects on small islands: PV pumping, telecommunications tower, individual house supply in conjuction with low-power consumption appliances
Italy	100,000 (early 1980s)			415 kW	Manufacturing and high-level research Demonstrations on islands on pumping, lighting and refrigeration
Netherlands	40,000 (1987)				
Norway				1,500 kW	PV power for secondary homes in remote areas
Romania				5 kW	Experimental PV system
United Kingdom of Great Britain and Northern Ireland			6,000 m^2(sales 1985)		

Country	Installed area (m^2)	Units installed	Manufacturing or sales/yr.	PV installed	Applications
USSR					Demonstration programme of 200 decentralized PV plants
Yugoslavia	243,800 (1988)		100,000 m^2		Domestic manufacturing of both solar water heaters and PV modules, capacities of 100,000 m^2 and about 1 MW a year respectively
Latin America and Caribbean					
Bolivia					Success with PV installations on altiplano, about 190 units for individual houses, cooperatively owned and some local manufacturing of parts
Dominican Republic					Good acceptance of PV-battery recharging systems and for direct lighting. 50 units have been installed
Peru				650 kW	
St. Lucia					More affluent home owners and hotels are increasingly installing solar water heaters

Country	Installed area (m^2)	Units installed	Manufacturing or sales/yr.	PV installed	Applications
United States of America			1,066,678 m^2 (1989)		12% of solar water collector production was for domestic solar water heaters, of which 33% was exported; and 41% for swimming pools California, Florida, Puerto Rico and Arizona have the most widespread use of solar water heaters The United States is the world's second largest producer of PV modules but exports, 80%, mainly for remote applications